

10-04-00

EL465851515

PTO/SB/05 (4/98)

Approved for use through 09/30/2000. OMB 0651-0032
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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No. MI22-1544

First Inventor or Application Identifier Guy T. Blalock

Title Plasma Etching Methods

Express Mail Label No. EL465851515

PTO

S. 1515

U.S.

09/07/00

10/02/00

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. * Fee Transmittal Form (e.g., PTO/SB/17)
(Submit an original and a duplicate for fee processing)
2. Specification [Total Pages 24]
(preferred arrangement set forth below)
 - Descriptive title of the Invention
 - Cross References to Related Applications
 - Statement Regarding Fed sponsored R & D
 - Reference to Microfiche Appendix
 - Background of the Invention
 - Brief Summary of the Invention
 - Brief Description of the Drawings (if filed)
 - Detailed Description
 - Claim(s)
 - Abstract of the Disclosure
3. Drawing(s) (35 U.S.C. 113) [Total Sheets 1]
4. Oath or Declaration [Total Pages 3]
- a. Newly executed (original or copy)
- b. Copy from a prior application (37 C.F.R. § 1.63(d))
(for continuation/divisional with Box 16 completed)
 - i. DELETION OF INVENTOR(S)
Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

* NOTE FOR ITEMS 1 & 13 IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).

ADDRESS TO: Assistant Commissioner for Patents
Box Patent Application
Washington, DC 20231

5. Microfiche Computer Program (Appendix)
6. Nucleotide and/or Amino Acid Sequence Submission
(if applicable, all necessary)
 - a. Computer Readable Copy
 - b. Paper Copy (identical to computer copy)
 - c. Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

7. Assignment Papers (cover sheet & document(s))
8. 37 C.F.R. § 3.73(b) Statement Power of (when there is an assignee) Attorney
9. English Translation Document (if applicable)
10. Information Disclosure Statement (IDS)/PTO-1449 Copies of IDS (IDS)/PTO-1449 Citations
11. Preliminary Amendment
12. Return Receipt Postcard (MPEP 503)
(Should be specifically itemized)
13. * Small Entity Statement(s) Statement filed in prior application (PTO/SB/09-12) Status still proper and desired
14. Certified Copy of Priority Document(s)
(if foreign priority is claimed)
15. Other: \$1472.00 check

16. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment:

Continuation Divisional Continuation-in-part (CIP) of prior application No: 09/141,775
Prior application information: Examiner L. Vinh Group / Art Unit: 1765

For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

17. CORRESPONDENCE ADDRESS

<input checked="" type="checkbox"/> Customer Number or Bar Code Label	021567		or <input type="checkbox"/> Correspondence address below (Insert Customer No. or Attach bar code label here)	
Name				
Address				
City	State	Zip Code		
Country	Telephone	Fax		

Name (Print/Type)	Bernard Berman	Registration No. (Attorney/Agent)	37,279
Signature			

Date Oct 2, 2000

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231.

FL465851515

PTO/JSB-7 (4/98)
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FEE TRANSMITTAL

for FY 1999

Patent fees are subject to annual revision.

Small Entity payments **must** be supported by a small entity statement, otherwise large entity fees must be paid. See Forms PTO/SB-09-12.

TOTAL AMOUNT OF PAYMENT (\$ 1472.00)

Complete if Known

Application Number

Filing Date

First Named Inventor

Examiner Name

Group / Art Unit

Attorney Docket No. MI22-1544



METHOD OF PAYMENT (check one)

1. The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:

Deposit Account Number 23-0925
Deposit Account Name Wells, St. John et al.

Charge Any Additional Fee Required Under 37 CFR 1.16 and 1.17

2. Payment Enclosed:

Check Money Order Other

FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
101	760	201	380
Utility filing fee			710
106	310	206	155
Design filing fee			
107	480	207	240
Plant filing fee			
108	760	208	380
Reissue filing fee			
114	150	214	75
Provisional filing fee			
SUBTOTAL (1) (\$)			710.00

2. EXTRA CLAIM FEES

Total Claims	Extra Claims	Fee from below	Fee Paid
49	-20**= 29	x 18	= 522
Independent Claims	6	-3***= 3	x 80 = 240
Multiple Dependent			= 0.00

**or number previously paid, if greater; For Reissues, see below

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description
103	18	203
Claims in excess of 20	9	
102	78	202
Independent claims in excess of 3	39	
104	260	204
Multiple dependent claim, if not paid	130	
109	78	209
**Reissue independent claims over original patent	39	
110	18	210
**Reissue claims in excess of 20 and over original patent	9	
SUBTOTAL (2) (\$)		
762.00		

3. ADDITIONAL FEES

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
105	130	205	65
Surcharge - late filing fee or oath			0.00
127	50	227	25
Surcharge - late provisional filing fee or cover sheet			0.00
139	130	139	130
Non-English specification			0.00
147	2,520	147	2,520
For filing a request for reexamination			0.00
112	920*	112	920*
Requesting publication of SIR prior to Examiner action			0.00
113	1,840*	113	1,840*
Requesting publication of SIR after Examiner action			0.00
115	110	215	55
Extension for reply within first month			0.00
116	380	216	190
Extension for reply within second month			0.00
117	870	217	435
Extension for reply within third month			0.00
118	1,360	218	680
Extension for reply within fourth month			0.00
128	1,850	228	925
Extension for reply within fifth month			0.00
119	300	219	150
Notice of Appeal			0.00
120	300	220	150
Filing a brief in support of an appeal			0.00
121	260	221	130
Request for oral hearing			0.00
138	1,510	138	1,510
Petition to institute a public use proceeding			0.00
140	110	240	55
Petition to revive - unavoidable			0.00
141	1,210	241	605
Petition to revive - unintentional			0.00
142	1,210	242	605
Utility issue fee (or reissue)			0.00
143	430	243	215
Design issue fee			0.00
144	580	244	290
Plant issue fee			0.00
122	130	122	130
Petitions to the Commissioner			0.00
123	50	123	50
Petitions related to provisional applications			0.00
126	240	126	240
Submission of Information Disclosure Stmt			0.00
581	40	581	40
Recording each patent assignment per property (times number of properties)			0.00
146	760	246	380
Filing a submission after final rejection (37 CFR 1.129(a))			0.00
149	760	249	380
For each additional invention to be examined (37 CFR 1.129(b))			0.00
Other fee (specify)			0.00
Other fee (specify)			0.00
*Reduced by Basic Filing Fee Paid			
SUBTOTAL (3) (\$)			0.00

SUBMITTED BY

Complete (if applicable)

Typed or Printed Name	Bernard Berman	Reg. Number	37,279
Signature		Date	Oct 2, 2002

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Priority Application Serial No. 09/141,775
Priority Filing Date August 27, 1998
Inventor Guy T. Blalock et al.
Priority Group Art Unit 1765
Priority Examiner L. Vinh
Attorney's Docket No. MI22-1544
Title: Plasma Etching Methods

PRELIMINARY AMENDMENT

To: Box Patent Application
Assistant Commissioner for Patents
Washington, D.C. 20231

From: Bernard Berman (Tel. 509-624-4276; Fax 509-838-3424)
Wells, St. John, Roberts, Gregory & Matkin P.S.
601 W. First Avenue, Suite 1300
Spokane, WA 99201-3828

Sir:

Please enter the following amendments prior to examining the above-identified application.

AMENDMENTS

In the Specification

At p. 1, before the "Technical Field" section, please replace the existing Related Applications section with the following:

--RELATED PATENT DATA

This patent is a continuation application of U.S. Patent Application Serial No. 09/141,775, which was filed on August 27, 1998, entitled "Plasma Etching Methods," naming Guy T. Blalock, David S. Becker, and

1 Kevin G. Donohoe as inventors, and which is now U.S. Patent No. ____
2 _____, the disclosure of which is incorporated by reference.

3

4 At page 7, line 23 before "conducted" insert --is--.

5

6 **In the Claims:**

7 Cancel claims 8, 9, 14, 15, 29, 43, 51 and 52 without prejudice.

8

9 Pending Claims 1-7, 10-13, 16-28, 30-42, 44-50 and 53-57 are
10 presented hereinbelow for the Examiner's benefit.

11

12 1. A plasma etching method comprising:
13 forming a polymer comprising carbon and a halogen over at least
14 some internal surfaces of a plasma etch chamber; and
15 after forming the polymer, plasma etching using a gas effective to
16 etch polymer from chamber internal surfaces; the gas having a hydrogen
17 component effective to form a gaseous hydrogen halide from halogen
18 liberated from the polymer.

19

20 2. The plasma etching method of claim 1 wherein the halogen
21 is selected from the group consisting of fluorine, chlorine and mixtures
22 thereof.

1 3. The plasma etching method of claim 1 wherein the halogen
2 comprises fluorine.

3
4 4. The plasma etching method of claim 1 wherein the gas also
5 comprises an oxygen component.

6
7 5. The plasma etching method of claim 1 wherein the gas also
8 comprises O₂.

9
10 6. The plasma etching method of claim 1 wherein the hydrogen
11 component comprises NH₃.

12
13 7. The plasma etching method of claim 1 wherein the hydrogen
14 component comprises H₂.

15
16 10. A plasma etching method comprising:
17 forming a polymer comprising carbon and a halogen over at least
18 some internal surfaces of a plasma etch chamber; and
19 after forming the polymer, plasma etching using a gas effective to
20 etch polymer from chamber internal surfaces; the gas comprising a
21 carbon compound effective to getter the halogen from the etched
22 polymer.

1 11. The plasma etching method of claim 10 wherein the gettering
2 comprises forming a gaseous hydrogen halide from the etched halogen.

3
4 12. The plasma etching method of claim 10 wherein the gettering
5 comprises forming a gaseous COA_x compound, where A is the etched
6 halogen.

7
8 13. The plasma etching method of claim 10 wherein the carbon
9 compound comprises a hydrocarbon.

10
11 16. The plasma etching method of claim 10 wherein the carbon
12 compound comprises a C-O bond.

13
14 17. The plasma etching method of claim 10 wherein the carbon
15 compound comprises CO.

16
17 18. The plasma etching method of claim 10 wherein the carbon
18 compound comprises CO formed from CO_2 injected into the chamber.

19
20 19. The plasma etching method of claim 10 wherein the halogen
21 comprises fluorine.

1 20. The plasma etching method of claim 10 wherein the gas also
2 comprises an oxygen component.

3
4 21. A plasma etching method comprising:
5 positioning a semiconductor wafer on a wafer receiver within a
6 plasma etch chamber;

7 first plasma etching material on the semiconductor wafer with a
8 gas comprising carbon and a halogen, a polymer comprising carbon and
9 the halogen forming over at least some internal surfaces of the plasma
10 etch chamber during the first plasma etching; and

11 after the first plasma etching and with the wafer on the wafer
12 receiver, second plasma etching using a gas effective to etch polymer
13 from chamber internal surfaces and getter halogen liberated from the
14 polymer to restrict further etching of the material on the semiconductor
15 wafer during the second plasma etching.

16
17 22. The plasma etching method of claim 21 wherein the receiver
18 is biased during the first plasma etching and provided at ground or
19 floating potential during the second plasma etching.

20
21 23. The plasma etching method of claim 21 wherein the gas
22 comprises hydrogen which combines with the halogen during the second
23 plasma etching to form a gaseous hydrogen halide.

1 24. The plasma etching method of claim 21 wherein the second
2 etching is conducted with a temperature of the receiver provided at from
3 about -10°C to about 40°C and at a chamber pressure of from about 30
4 mTorr to about 5 Torr.

5
6 25. The plasma etching method of claim 21 wherein the halogen
7 comprises fluorine.

8
9 26. The plasma etching method of claim 21 wherein the gas
10 comprises an oxygen component.

11
12 27. The plasma etching method of claim 21 wherein the gas
13 comprises NH₃, with hydrogen from the NH₃ combining with the halogen
14 during the second plasma etching to form a gaseous hydrogen halide.

15
16 28. The plasma etching method of claim 21 wherein the gas
17 comprises H₂ which combines with the halogen during the second plasma
18 etching to form a gaseous hydrogen halide.

1 30. The plasma etching method of claim 21 wherein the first and
2 second plasma etchings are conducted at subatmospheric pressure, and
3 the wafer remaining *in situ* on the receiver intermediate the first and
4 second etchings, and maintaining the chamber at a subatmospheric
5 pressure at all time intermediate the first and second plasma etchings.

6

7 31. The plasma etching method of claim 21 wherein the gettering
8 comprises forming a gaseous COA_x compound, where A is the etched
9 halogen.

10

11 32. The plasma etching method of claim 21 wherein the gas
12 comprises a carbon compound effective for the gettering.

13

14 33. The plasma etching method of claim 32 wherein the carbon
15 compound comprises a hydrocarbon.

16

17 34. The plasma etching method of claim 32 wherein the carbon
18 compound comprises a C-O bond.

19

20 35. The plasma etching method of claim 32 wherein the carbon
21 compound comprises CO.

1 36. A plasma etching method comprising:
2 positioning a semiconductor wafer on a wafer receiver within a
3 plasma etch chamber, the semiconductor wafer having a photoresist layer
4 formed thereon;

5 first plasma etching material on the semiconductor wafer through
6 openings formed in the photoresist layer with a gas comprising carbon
7 and a halogen, a polymer comprising carbon and the halogen forming
8 over at least some internal surfaces of the plasma etch chamber during
9 the first plasma etching; and

10 after the first plasma etching and with the wafer on the wafer
11 receiver, second plasma etching using a gas having one or more
12 components effective to etch photoresist from the substrate and polymer
13 from chamber internal surfaces and getter halogen liberated from the
14 polymer to restrict further etching of the material on the semiconductor
15 wafer during the second plasma etching.

16
17 37. The plasma etching method of claim 36 one of the gas
18 components comprises hydrogen which combines with the halogen during
19 the second plasma etching to form a gaseous hydrogen halide.

20
21 38. The plasma etching method of claim 36 wherein one of the
22 gas components comprises O₂ and another is hydrogen atom containing.

1 39. The plasma etching method of claim 36 wherein one of the
2 gas components comprises O₂ and another is hydrogen atom containing,
3 said one component and said another component being provided in the
4 chamber during the second plasma etching at a volumetric ratio of the
5 one to the another of at least 0.1:1.

6

7 40. The plasma etching method of claim 36 wherein the halogen
8 comprises fluorine.

9

10 41. The plasma etching method of claim 36 wherein one of the
11 gas components comprises NH₃, with hydrogen from the NH₃ combining
12 with the halogen during the second plasma etching to form a gaseous
13 hydrogen halide.

14

15 42. The plasma etching method of claim 36 wherein one of the
16 gas components comprises H₂ which combines with the halogen during
17 the second plasma etching to form a gaseous hydrogen halide.

18

19 44. The plasma etching method of claim 36 wherein the first and
20 second plasma etchings are conducted at subatmospheric pressure, and
21 the wafer remaining *in situ* on the receiver intermediate the first and
22 second etchings, and maintaining the chamber at a subatmospheric
23 pressure at all time intermediate the first and second plasma etchings.

1 45. The plasma etching method of claim 36 wherein the gettering
2 comprises forming a gaseous COA_x compound, where A is the etched
3 halogen.

4
5 46. The plasma etching method of claim 36 wherein the gas
6 comprises a carbon compound effective for the gettering.

1 47. A plasma etching method comprising:

2 positioning a semiconductor wafer on an electrostatic chuck within
3 an inductively coupled plasma etch chamber, the semiconductor wafer
4 having a photoresist layer formed on an insulative oxide layer, the
5 photoresist layer having contact opening patterns formed therethrough;

6 first plasma etching contact openings within the insulative oxide on
7 the semiconductor wafer through the contact opening patterns formed in
8 the photoresist layer with a gas comprising carbon and fluorine, a
9 polymer comprising carbon and fluorine forming over at least some
10 internal surfaces of the plasma etch chamber during the first plasma
11 etching; and

12 after the first plasma etching and with the wafer on the
13 electrostatic chuck, providing the electrostatic chuck at ground or floating
14 potential while second plasma etching using a gas comprising an oxygen
15 component and a hydrogen component effective to etch photoresist from
16 the substrate and polymer from chamber internal surfaces, and forming
17 HF during the second plasma etching from fluorine liberated from the
18 polymer to restrict widening of the contact openings formed in the
19 insulative oxide resulting from further etching of the material on the
20 semiconductor wafer during the second plasma etching.

21

22 48. The plasma etching method of claim 47 wherein the oxygen
23 comprises O₂.

1 49. The plasma etching method of claim 47 wherein the hydrogen
2 component comprises NH₃.

3

4 50. The plasma etching method of claim 47 wherein the hydrogen
5 component comprises H₂.

6

7 53. The plasma etching method of claim 47 wherein the first and
8 second plasma etchings are conducted at subatmospheric pressure, and
9 the wafer remaining *in situ* on the electrostatic chuck intermediate the
10 first and second etchings, and maintaining the chamber at a
11 subatmospheric pressure at all time intermediate the first and second
12 plasma etchings.

1 54. A plasma etching method comprising:

2 positioning a semiconductor wafer on an electrostatic chuck within
3 an inductively coupled plasma etch chamber, the semiconductor wafer
4 having a photoresist layer formed on an insulative oxide layer, the
5 photoresist layer having contact opening patterns formed therethrough;

6 first plasma etching contact openings within the insulative oxide on
7 the semiconductor wafer through the contact opening patterns formed in
8 the photoresist layer with a gas comprising carbon and fluorine, a
9 polymer comprising carbon and fluorine forming over at least some
10 internal surfaces of the plasma etch chamber during the first plasma
11 etching; and

12 after the first plasma etching and with the wafer on the
13 electrostatic chuck, providing the electrostatic chuck at ground or floating
14 potential while second plasma etching using a gas comprising an oxygen
15 component and a carbon component effective to etch photoresist from
16 the substrate and polymer from chamber internal surfaces, and gettering
17 fluorine liberated from the polymer during the second plasma etching
18 with the carbon component to restrict widening of the contact openings
19 formed in the insulative oxide resulting from further etching of the
20 material on the semiconductor wafer during the second plasma etching.

21
22 55. The plasma etching method of claim 54 wherein the gettering
23 comprises forming a gaseous hydrogen halide from the etched halogen.

1 56. The plasma etching method of claim 54 wherein the gettering
2 comprises forming a gaseous COA_x compound, where A is the etched
3 halogen.

4

5 57. The plasma etching method of claim 54 wherein the carbon
6 compound comprises a C-O bond.

REMARKS

This application is a continuation application of U.S. Patent Application Serial No. 09/141,775, filed August 27, 1998. Claims 8, 9, 14, 15, 29, 43, 51 and 52 have been canceled without prejudice. Claims 1-7, 10-13, 16-28, 30-42, 44-50 and 53-57 are pending herein.

In an Office Action mailed August 25, 2000, Claims 1-7, 10-13, 16-28, 30-42, 44-50 and 53-57 were rejected under 35 U.S.C. §103(a) as being unpatentable under various combinations of Keller (U.S. Patent No. 5,644,153), Xia et al. (U.S. Patent No. 5,935,340, hereinafter “Xia”) and Saito et al. (U.S. Patent No. 5,681,424, hereinafter “Saito”).

The Examiner alleged that the plasma etching method disclosed by Keller encompass plasma etching a semiconductor wafer with a plasma etching material where a polymer of carbon and halogen are formed over an etching chamber's internal surfaces. The Examiner further alleged that the method of Keller also disclosed plasma etching with a gas effective to etch/clean the polymer formed on the chamber's surfaces, although such effective gas does not disclose that a gaseous hydrogen halide product of such etch/clean is formed. Rather the Examiner alleges that Xia disclosed such an effective gas, specifically at column 59, lines 47-50 and alleged further, that one skilled in the art would have found it obvious to use Keller's gas having a hydrogen component to form a hydrogen halide in view of Xia. Applicant DISAGREES.

1 As the Examiner admitted on page 3, line 2 of the
2 above-referenced Office Action, Keller's gas having a hydrogen component
3 is HBr, a gas containing both hydrogen and a halogen, specifically
4 bromine. Hence Applicant respectfully asserts that such a gas cannot be
5 effective by itself to remove a halogen from the polymer as the
6 stoichiometry of HBr dictates that for each hydrogen introduced, a
7 halogen is introduced, therefore there can be NO net removal of halogen
8 using such a gas. Rather, if such a gas were to react with a halogen
9 contained within a polymer, at best the halogen of the polymer would
10 only be exchanged for the bromine of the HBr.

11 In addition, Applicant notes that the process disclosed by Xia is
12 not a plasma etching process as described by Keller. Rather Xia
13 discloses a method for HIGH TEMPERATURE PROCESSING.
14 Specifically, the process disclosed at the portion of Xia referred to by
15 the Examiner is performed at a preferred temperature range of 550 to
16 600°C, a temperature at which the wafers being processed by Keller are
17 likely to be damaged due to the decomposition of the photoresist Keller
18 teaches is used as an etch mask. Hence, Applicant asserts that a
19 combination of Keller and Xia would NOT be obvious, as a skilled
20 practitioner of the etching arts would know that (1) HBr would not be
21 expected to cause any net reduction in halogen content as it introduces
22 as much halogen as it can remove, and (2) the high temperature process

1 of Xia cannot be combined with the etching process of Keller as such
2 would, at the very least, severely damage the photoresist masking layer.

3 The Examiner also refers, in the rejection of some claims, to Saito.
4 Specifically the Examiner alleges that Saito discloses the use of oxygen,
5 not disclosed in either of Keller or Xia. The Examiner then alleges that
6 it would have been obvious for one skilled in the art to combine the
7 oxygen disclosed by Saito with the method resulting from the
8 combination of Keller and Xia. Applicant DISAGREES. Keller
9 specifically teaches that the two step process disclosed is to provide
10 improved critical dimension control of the etched material. Keller
11 provides such improved control by providing a second etching step which
12 functions "to remove non-uniformities that remain after the primary etch"
13 (col. 4, lines 41-42). The second etching step has a lower etch rate,
14 with respect to the silicon nitride being etched, than the first etching
15 step (id., lines 48-49) and additionally removes most of the polymer
16 formed on the sidewalls of the etched structure during the first etching
17 step (id. lines 56-57). However, as oxygen introduced into a plasma
18 etching chamber is well known as a method for removing photoresist,
19 Applicant asserts that such an introduction in the second etching step
20 of Keller would, at the very least, remove some of the photoresist mask
21 and thus cause such second etching step to alter the critical dimension
22 of the structure formed by the etching of the first step. It is also well
23 known that the rate of such photoresist removal is enhanced by high

1 temperatures so that it is likely that the high temperatures taught by Xia
2 would dramatically increase such a removal rate. Thus, Applicant asserts
3 that rather than a combination that would be obvious to a skilled
4 practitioner, the Examiner's proposed combination would prevent the
5 method of Keller from achieving the result to which it is directed.

6 In summary, Applicant presents Claims 1-7, 10-13, 16-28, 30-42,
7 44-50 and 53-57 for consideration in this Continuation Application.
8 Additionally, Applicant respectfully asserts that in view of the remarks
9 presented above, a rejection of such claims based on ANY combination
10 of Keller, Xia and Saito is inappropriate as such combinations cannot be
11 suggested where they prevent the result sought by any one of the
12 references cited. Such has been shown above. Applicant therefore
13 asserts that such claims are in condition for allowance as presented,
14 which action is earnestly sought.

15
16 Respectfully submitted,

17
18 Dated Oct 2, 2000

19 By: 
20 Bernard Berman
21 Reg. No. 37,279
22
23

EL54831987

EL465851515

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION FOR LETTERS PATENT

* * * * *

Plasma Etching Methods

* * * * *

INVENTORS

**Guy T. Blalock
David S. Becker
Kevin G. Donohoe**

ATTORNEY'S DOCKET NO. MI22-776

PLASMA ETCHING METHODS

TECHNICAL FIELD

This invention relates to plasma etching methods.

BACKGROUND OF THE INVENTION

Plasma etchers are commonly used in semiconductor wafer processing for fabrication of contact openings through insulating layers. A photoresist layer having contact opening patterns formed therethrough is typically formed over an insulative oxide layer, such as SiO_2 and doped SiO_2 . An oxide etching gas, for example CF_4 , is provided within the etcher and a plasma generated therefrom over the wafer or wafers being processed. The etching gas chemistry in combination with the plasma is ideally chosen to be highly selective to etch the insulating material through the photoresist openings in a highly anisotropic manner without appreciably etching the photoresist itself. A greater degree of anisotropy is typically obtained with such dry plasma etchings of contact openings than would otherwise occur with wet etching techniques.

One type of plasma etcher includes inductively coupled etching reactors. Such typically include an inductive plasma generating source coiled about or at the top of the reactor chamber and an electrostatic chuck within the chamber atop which one or more wafers being processed lies. The electrostatic chuck can be selectively biased as determined by the operator. Unfortunately when utilizing etching components having both carbon and fluorine, particularly in inductively

coupled etching reactors, a halocarbon polymer develops over much of the internal reactor sidewall surfaces. This polymer continually grows in thickness with successive processing. Due to instabilities in the polymer film, the films are prone to flaking causing particulate contamination. In addition, the build-up of these films can produce process instabilities which are desirably avoided.

The typical prior art process for cleaning this polymer material from the reactor employs a plasma etch utilizing O₂ as the etching gas. It is desirable that this clean occur at the conclusion of etching of the wafer while the wafer or wafers remain *in situ* within the reactor chamber. This both protects the electrostatic chuck (which is sensitive to particulate contamination) during the clean etch, and also maximizes throughput of the wafers being processed. An added benefit is obtained in that the oxygen plasma generated during the clean also has the effect of stripping the photoresist from the over the previously etched wafer.

However in the process of doing this reactor clean etch, there is an approximate 0.025 micron or greater loss in the lateral direction of the contact. In otherwords, the contact openings within the insulating layer are effectively widened from the opening dimensions as initially formed. This results in an inherent increase in the critical dimension of the circuitry design. As contact openings become smaller, it is not expected that the photolithography processing will be able to adjust in further increments of size to compensate for this critical dimension loss.

1 Accordingly, it would be desirable to develop plasma etching
2 methods which can be used to minimize critical dimension loss of
3 contact openings, and/or achieve suitable reactor cleaning to remove the
4 polymer from the internal surfaces of the etching chamber. Although
5 the invention was motivated from this perspective, the artisan will
6 appreciate other possible uses with the invention only be limited by the
7 accompanying claims appropriately interpreted in accordance with the
8 Doctrine of Equivalents.

9

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11

12 **BRIEF DESCRIPTION OF THE DRAWINGS**

13 Preferred embodiments of the invention are described below with
14 reference to the following accompanying drawings.

15 Fig. 1 is a diagrammatic view of a plasma etcher utilized at one
16 processing step in accordance with the invention.

17 Fig. 2 is a view of the Fig. 1 apparatus and wafer at a
18 processing step subsequent to that depicted by Fig. 1.

1 **SUMMARY OF THE INVENTION**

2 In but one aspect of the invention, a plasma etching method
3 includes forming a polymer comprising carbon and a halogen over at
4 least some internal surfaces of a plasma etch chamber. After forming
5 the polymer, plasma etching is conducted using a gas which is effective
6 to etch polymer from chamber internal surfaces. In one implementation,
7 the gas has a hydrogen component effective to form a gaseous hydrogen
8 halide from halogen liberated from the polymer. The hydrogen
9 component is preferably one or more of H_2 , NH_3 and CH_4 . The
10 conversion of the halogen, released from the clean into a hydrogen
11 halide, renders it substantially ineffective in etching the substrate and
12 thus reduces the critical dimension loss. In one implementation, the gas
13 comprises a carbon component effective to getter the halogen from the
14 etched polymer.

15 In another implementation, a plasma etching method includes
16 positioning a semiconductor wafer on a wafer receiver within a plasma
17 etch chamber. First plasma etching of material on the semiconductor
18 wafer occurs with a gas comprising carbon and a halogen. A polymer
19 comprising carbon and the halogen forms over at least some internal
20 surfaces of the plasma etch chamber during the first plasma etching.
21 After the first plasma etching and with the wafer on the wafer receiver,
22 second plasma etching is conducted using a gas effective to etch
23 polymer from chamber internal surfaces and getter halogen liberated
24 from the polymer to restrict further etching of the material on the

1 semiconductor wafer during the second plasma etching. The first and
2 second plasma etchings are ideally conducted at subatmospheric pressure
3 with the wafer remaining *in situ* on the receiver intermediate the first
4 and second etchings, and with the chamber maintained at some
5 subatmospheric pressure at all time intermediate the first and second
6 plasma etchings.

7 The halogen preferably comprises fluorine, chlorine or mixtures
8 thereof. The gas at least during the second etching preferably includes
9 oxygen, such as O₂.

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12 **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

13 This disclosure of the invention is submitted in furtherance of the
14 constitutional purposes of the U.S. Patent Laws "to promote the
15 progress of science and useful arts" (Article 1, Section 8).

16 It has been discovered that the polymer deposited on the internal
17 walls of the etching chamber includes a significant concentration of
18 fluorine. It is believed that the oxygen during the clean etching under
19 plasma condition combines with the carbon and fluorine of the polymer
20 liberated from the internal walls and forms carbon monoxide and carbon
21 dioxide plus an activated or reactive fluorine species. Unfortunately,
22 this liberated fluorine species is also apparently reactive with the silicon
23 dioxide material on the wafer, which results in more etching of such
24 material and the widening of the contact openings.

1 Referring to Fig. 1, a plasma etching reactor is indicated generally
2 with reference numeral 10. Such includes sidewalls 12 having internal
3 surfaces 14. One or more gas inlets 16 and one or more gas
4 outlets 18 are provided relative to etching chamber 12. A pump 20
5 is associated with outlet 18 for exhausting and establishing desired
6 subatmospheric pressure conditions within chamber 12 during processing.

7 Plasma etching reactor 10 in the described embodiment is
8 configured as an inductively coupled plasma etcher having a wafer
9 receiver 22 within chamber 12 in the form of an electrostatic chuck.
10 A biasing source 24 is electrically coupled with receiver 22. An
11 inductive plasma inducing source 26 is diagrammatically shown externally
12 at the top of chamber 10.

13 In accordance with the preferred embodiment, a semiconductor
14 wafer 30 is positioned upon wafer receiver 22 within chamber 12.
15 Wafer 30 has previously been processed to have a photoresist layer 32
16 formed on an insulative oxide layer (not specifically shown) formed on
17 the outer surface of wafer 30. Photoresist layer 32 has contact opening
18 patterns (not specifically shown) formed therethrough which ideally
19 outwardly expose selected portions of the underlying insulative oxide
20 layer.

21 A desired vacuum pressure is established and maintained within
22 chamber 12 utilizing vacuum pump 20. An example chamber pressure
23 is from about 30 mTorr to about 5 Torr. Inductively coupled
24 source 26 and chuck 22 are appropriately biased to enable establishment

1 of a desired plasma within and immediately over wafer 30. An example
2 power range for inductively coupled source 26 is from 100 watts to
3 about 2,000 watts, with wafer receiver 22 being negatively biased to an
4 example of 100 - 400 volts. Receiver 22 can have a temperature which
5 is allowed to float, or otherwise be established and maintained at some
6 range, for example from about -10°C to about 40°C.

7 Desired etching gases are injected to within chamber 12 through
8 inlet 16, or other inlets, to provide a desired etching gas from which
9 an etching plasma is formed immediately over wafer 30. Such gas can
10 comprise, for example, carbon and a halogen. An exemplary gas would
11 be CF_4 . Etching is conducted for a selected time to etch contact
12 openings within the insulative oxide material on semiconductor wafer 30
13 through the contact opening patterns formed within photoresist layer 32.
14 Unfortunately, a polymer layer 40 comprising carbon and the halogen,
15 in this example fluorine, forms over some of internal surfaces 14 of
16 plasma etch chamber 12 during such etching. Such polymer can also
17 form over photoresist layer 32 (not specifically shown). Such provides
18 but one example of forming a polymer comprising carbon and a halogen
19 over at least some internal surfaces of a plasma etch chamber.

20 Referring to Fig. 2, and at the conclusion of the first plasma
21 etching and with wafer 30 on electrostatic chuck 22, chuck 22 is ideally
22 provided at ground or floating potential and second plasma etching
23 is conducted using a gas effective to etch polymer from chamber internal
24 surfaces 14. The gas ideally has one or more components effective to

1 etch photoresist layer 32 from substrate 30 and polymer from chamber
2 internal surfaces 14 (both being shown as removed in Fig. 2). Further,
3 such one or more components of the gas are selected to be effective
4 to getter halogen liberated from the polymer to restrict further etching
5 of the insulative oxide or other previously etched material on the
6 semiconductor wafer during the second plasma etching.

7 In one example, the gettering component comprises hydrogen which
8 combines with the halogen during the second plasma etching to form
9 a gaseous hydrogen halide which has a low reactivity with material of
10 the semiconductor wafer, and accordingly is withdrawn from the reactor
11 through outlet 18. Example hydrogen atom containing gases include
12 NH₃, H₂, and CH₄. One example gas for providing the hydrogen
13 component to the chamber is forming gas which consists essentially of
14 N₂ at about 96% or greater and H₂ at about 4% or less, by volume.

15 In another example, the gettering component comprises a carbon
16 compound. Examples include hydrocarbons, aldehydes (i.e.,
17 formaldehyde) and ketones (i.e., methyl ketone). Hydrocarbons will
18 typically getter the halogen as a hydrogen halide. Where the carbon
19 compound comprises a C-O bond which survives the processing, the
20 halogen will typically be gettered as COA_X, where A is the etched
21 halogen. One example carbon containing gettering compound having a
22 C-O bond is CO, produced for example within the plasma from injecting
23 CO₂ to within the reactor.

1 The gas also ideally comprises an additional oxygen component,
2 such as O₂ or other material. Such facilitates etching of both polymer
3 and photoresist over the substrate. Where the gas components comprise
4 O₂ and a hydrogen atom containing component, the O₂ component and
5 hydrogen atom containing component are preferably provided in the
6 chamber during the second plasma etching at a volumetric ratio of at
7 least 0.1:1 of O₂ to the hydrogen atom containing component. One
8 reduction to practice example in a thirty-five liter high density plasma
9 etcher included a feed for the second plasma etching of 60 sccm NH₃
10 sccm DB 8/24/98
11 and 1,000 liters per minute of O₂. For a carbon containing compound,
12 such is preferably provided at from about 5% to about 80% by volume
13 of the oxygen/carbon compound mixture.

14 Plasma conditions within the chamber with respect to pressure and
15 temperature and biasing power on induction source 26 can be the same
16 as in the first etching, or different. Regardless, such first and second
17 plasma etchings are ideally conducted at subatmospheric pressure where
18 the wafer remains *in situ* on the electrostatic chuck intermediate the
19 first and second etchings with the chamber being maintained at some
20 subatmospheric pressure at all time intermediate the first and second
21 plasma etchings.

22 In compliance with the statute, the invention has been described
23 in language more or less specific as to structural and methodical
24 features. It is to be understood, however, that the invention is not
25 limited to the specific features shown and described, since the means

1 herein disclosed comprise preferred forms of putting the invention into
2 effect. The invention is, therefore, claimed in any of its forms or
3 modifications within the proper scope of the appended claims
4 appropriately interpreted in accordance with the doctrine of equivalents.

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1 **CLAIMS:**

2 1. A plasma etching method comprising:
3 forming a polymer comprising carbon and a halogen over at least
4 some internal surfaces of a plasma etch chamber; and
5 after forming the polymer, plasma etching using a gas effective to
6 etch polymer from chamber internal surfaces; the gas having a hydrogen
7 component effective to form a gaseous hydrogen halide from halogen
8 liberated from the polymer.

9
10 2. The plasma etching method of claim 1 wherein the halogen
11 is selected from the group consisting of fluorine, chlorine and mixtures
12 thereof.

13
14 3. The plasma etching method of claim 1 wherein the halogen
15 comprises fluorine.

16
17 4. The plasma etching method of claim 1 wherein the gas also
18 comprises an oxygen component.

19
20 5. The plasma etching method of claim 1 wherein the gas also
21 comprises O_2 .

22
23 6. The plasma etching method of claim 1 wherein the hydrogen
24 component comprises NH_3 .

1 7. The plasma etching method of claim 1 wherein the hydrogen
2 component comprises H₂.

3

4 8. The plasma etching method of claim 1 wherein the hydrogen
5 component comprises forming gas consisting essentially of N₂ at about
6 96% or greater and H₂ at about 4% or less, by volume.

7

8 9. The plasma etching method of claim 1 wherein the hydrogen
9 component comprises CH₄.

10

11 10. A plasma etching method comprising:
12 forming a polymer comprising carbon and a halogen over at least
13 some internal surfaces of a plasma etch chamber; and
14 after forming the polymer, plasma etching using a gas effective to
15 etch polymer from chamber internal surfaces; the gas comprising a
16 carbon compound effective to getter the halogen from the etched
17 polymer.

18

19 11. The plasma etching method of claim 10 wherein the
20 gettering comprises forming a gaseous hydrogen halide from the etched
21 halogen.

12. The plasma etching method of claim 10 wherein the
gettering comprises forming a gaseous COA_x compound, where A is the
etched halogen.

13. The plasma etching method of claim 10 wherein the carbon
compound comprises a hydrocarbon.

14. The plasma etching method of claim 10 wherein the carbon
compound comprises an aldehyde.

15. The plasma etching method of claim 10 wherein the carbon
compound comprises a ketone.

16. The plasma etching method of claim 10 wherein the carbon
compound comprises a C-O bond.

17. The plasma etching method of claim 10 wherein the carbon
compound comprises CO.

18. The plasma etching method of claim 10 wherein the carbon
compound comprises CO formed from CO_2 injected into the chamber.

19. The plasma etching method of claim 10 wherein the halogen
comprises fluorine.

1 20. The plasma etching method of claim 10 wherein the gas
2 also comprises an oxygen component.

3
4 21. A plasma etching method comprising:
5 positioning a semiconductor wafer on a wafer receiver within a
6 plasma etch chamber;

7 first plasma etching material on the semiconductor wafer with a
8 gas comprising carbon and a halogen, a polymer comprising carbon and
9 the halogen forming over at least some internal surfaces of the plasma
10 etch chamber during the first plasma etching; and

11 after the first plasma etching and with the wafer on the wafer
12 receiver, second plasma etching using a gas effective to etch polymer
13 from chamber internal surfaces and getter halogen liberated from the
14 polymer to restrict further etching of the material on the semiconductor
15 wafer during the second plasma etching.

16
17 22. The plasma etching method of claim 21 wherein the receiver
18 is biased during the first plasma etching and provided at ground or
19 floating potential during the second plasma etching.

20
21 23. The plasma etching method of claim 21 wherein the gas
22 comprises hydrogen which combines with the halogen during the second
23 plasma etching to form a gaseous hydrogen halide.

1 24. The plasma etching method of claim 21 wherein the second
2 etching is conducted with a temperature of the receiver provided at
3 from about -10°C to about 40°C and at a chamber pressure of from
4 about 30 mTorr to about 5 Torr.

5
6 25. The plasma etching method of claim 21 wherein the halogen
7 comprises fluorine.

8
9 26. The plasma etching method of claim 21 wherein the gas
10 comprises an oxygen component.

11
12 27. The plasma etching method of claim 21 wherein the gas
13 comprises NH₃, with hydrogen from the NH₃ combining with the
14 halogen during the second plasma etching to form a gaseous hydrogen
15 halide.

16
17 28. The plasma etching method of claim 21 wherein the gas
18 comprises H₂ which combines with the halogen during the second
19 plasma etching to form a gaseous hydrogen halide.

20
21 29. The plasma etching method of claim 21 wherein the gas
22 comprises CH₄, with hydrogen from the CH₄ combining with the
23 halogen during the second plasma etching to form a gaseous hydrogen
24 halide.

1 30. The plasma etching method of claim 21 wherein the first
2 and second plasma etchings are conducted at subatmospheric pressure,
3 and the wafer remaining *in situ* on the receiver intermediate the first
4 and second etchings, and maintaining the chamber at a subatmospheric
5 pressure at all time intermediate the first and second plasma etchings.

6
7 31. The plasma etching method of claim 21 wherein the
8 gettering comprises forming a gaseous COA_x compound, where A is the
9 etched halogen.

10
11 32. The plasma etching method of claim 21 wherein the gas
12 comprises a carbon compound effective for the gettering.

13
14 33. The plasma etching method of claim 32 wherein the carbon
15 compound comprises a hydrocarbon.

16
17 34. The plasma etching method of claim 32 wherein the carbon
18 compound comprises a C-O bond.

19
20 35. The plasma etching method of claim 32 wherein the carbon
21 compound comprises CO.

1 36. A plasma etching method comprising:
2 positioning a semiconductor wafer on a wafer receiver within a
3 plasma etch chamber, the semiconductor wafer having a photoresist layer
4 formed thereon;

5 first plasma etching material on the semiconductor wafer through
6 openings formed in the photoresist layer with a gas comprising carbon
7 and a halogen, a polymer comprising carbon and the halogen forming
8 over at least some internal surfaces of the plasma etch chamber during
9 the first plasma etching; and

10 after the first plasma etching and with the wafer on the wafer
11 receiver, second plasma etching using a gas having one or more
12 components effective to etch photoresist from the substrate and polymer
13 from chamber internal surfaces and getter halogen liberated from the
14 polymer to restrict further etching of the material on the semiconductor
15 wafer during the second plasma etching.

16
17 37. The plasma etching method of claim 36 one of the gas
18 components comprises hydrogen which combines with the halogen during
19 the second plasma etching to form a gaseous hydrogen halide.

20
21 38. The plasma etching method of claim 36 wherein one of the
22 gas components comprises O_2 and another is hydrogen atom containing.

1 39. The plasma etching method of claim 36 wherein one of the
2 gas components comprises O_2 and another is hydrogen atom containing,
3 said one component and said another component being provided in the
4 chamber during the second plasma etching at a volumetric ratio of the
5 one to the another of at least 0.1:1.

6

7 40. The plasma etching method of claim 36 wherein the halogen
8 comprises fluorine.

9

10 41. The plasma etching method of claim 36 wherein one of the
11 gas components comprises NH_3 , with hydrogen from the NH_3 combining
12 with the halogen during the second plasma etching to form a gaseous
13 hydrogen halide.

14

15 42. The plasma etching method of claim 36 wherein one of the
16 gas components comprises H_2 which combines with the halogen during
17 the second plasma etching to form a gaseous hydrogen halide.

18

19 43. The plasma etching method of claim 36 wherein one of the
20 gas components comprises CH_4 , with hydrogen from the CH_4 combining
21 with the halogen during the second plasma etching to form a gaseous
22 hydrogen halide.

1 44. The plasma etching method of claim 36 wherein the first
2 and second plasma etchings are conducted at subatmospheric pressure,
3 and the wafer remaining *in situ* on the receiver intermediate the first
4 and second etchings, and maintaining the chamber at a subatmospheric
5 pressure at all time intermediate the first and second plasma etchings.

6
7 45. The plasma etching method of claim 36 wherein the
8 gettering comprises forming a gaseous COA_x compound, where A is the
9 etched halogen.

10
11 46. The plasma etching method of claim 36 wherein the gas
12 comprises a carbon compound effective for the gettering.

1 47. A plasma etching method comprising:

2 positioning a semiconductor wafer on an electrostatic chuck within
3 an inductively coupled plasma etch chamber, the semiconductor wafer
4 having a photoresist layer formed on an insulative oxide layer, the
5 photoresist layer having contact opening patterns formed therethrough;

6 first plasma etching contact openings within the insulative oxide
7 on the semiconductor wafer through the contact opening patterns formed
8 in the photoresist layer with a gas comprising carbon and fluorine, a
9 polymer comprising carbon and fluorine forming over at least some
10 internal surfaces of the plasma etch chamber during the first plasma
11 etching; and

12 after the first plasma etching and with the wafer on the
13 electrostatic chuck, providing the electrostatic chuck at ground or
14 floating potential while second plasma etching using a gas comprising an
15 oxygen component and a hydrogen component effective to etch
16 photoresist from the substrate and polymer from chamber internal
17 surfaces, and forming HF during the second plasma etching from
18 fluorine liberated from the polymer to restrict widening of the contact
19 openings formed in the insulative oxide resulting from further etching
20 of the material on the semiconductor wafer during the second plasma
21 etching.

22
23 48. The plasma etching method of claim 47 wherein the oxygen
24 comprises O₂.

1 49. The plasma etching method of claim 47 wherein the
2 hydrogen component comprises NH_3 .

3
4 50. The plasma etching method of claim 47 wherein the
5 hydrogen component comprises H_2 .

6
7 51. The plasma etching method of claim 47 wherein the
8 hydrogen component comprises forming gas consisting essentially of N_2
9 at about 96% or greater and H_2 at about 4% or less, by volume.

10
11 52. The plasma etching method of claim 47 wherein the
12 hydrogen component comprises CH_4 .

13
14 53. The plasma etching method of claim 47 wherein the first
15 and second plasma etchings are conducted at subatmospheric pressure,
16 and the wafer remaining *in situ* on the electrostatic chuck intermediate
17 the first and second etchings, and maintaining the chamber at a
18 subatmospheric pressure at all time intermediate the first and second
19 plasma etchings.

1 54. A plasma etching method comprising:

2 positioning a semiconductor wafer on an electrostatic chuck within
3 an inductively coupled plasma etch chamber, the semiconductor wafer
4 having a photoresist layer formed on an insulative oxide layer, the
5 photoresist layer having contact opening patterns formed therethrough;

6 first plasma etching contact openings within the insulative oxide
7 on the semiconductor wafer through the contact opening patterns formed
8 in the photoresist layer with a gas comprising carbon and fluorine, a
9 polymer comprising carbon and fluorine forming over at least some
10 internal surfaces of the plasma etch chamber during the first plasma
11 etching; and

12 after the first plasma etching and with the wafer on the
13 electrostatic chuck, providing the electrostatic chuck at ground or
14 floating potential while second plasma etching using a gas comprising an
15 oxygen component and a carbon component effective to etch photoresist
16 from the substrate and polymer from chamber internal surfaces, and
17 gettering fluorine liberated from the polymer during the second plasma
18 etching with the carbon component to restrict widening of the contact
19 openings formed in the insulative oxide resulting from further etching
20 of the material on the semiconductor wafer during the second plasma
21 etching.

1 55. The plasma etching method of claim 54 wherein the
2 gettering comprises forming a gaseous hydrogen halide from the etched
3 halogen.

4
5 56. The plasma etching method of claim 54 wherein the
6 gettering comprises forming a gaseous COA_x compound, where A is the
7 etched halogen.

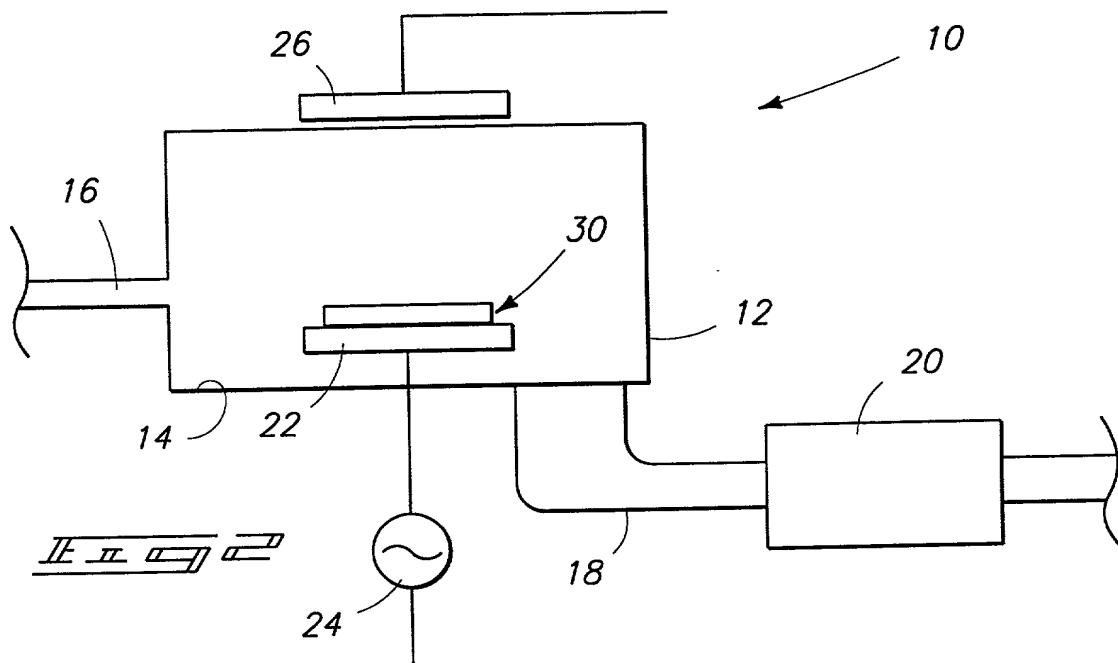
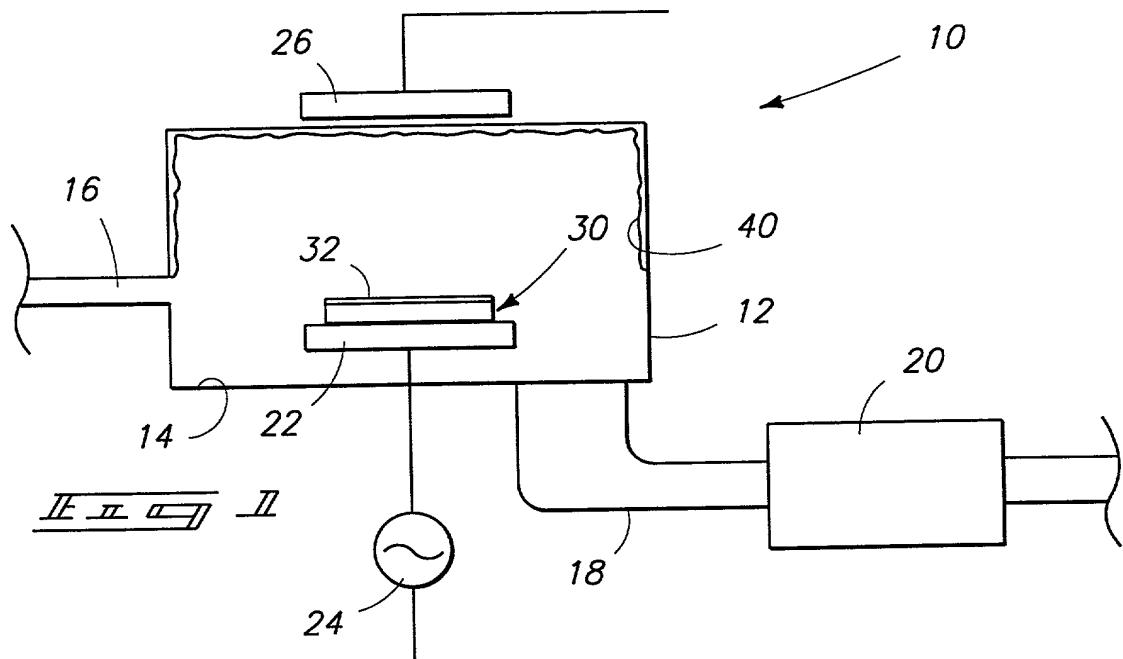
8
9 57. The plasma etching method of claim 54 wherein the carbon
10 compound comprises a C-O bond.

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1 **ABSTRACT OF THE DISCLOSURE**

2 A plasma etching method includes forming a polymer comprising
3 carbon and a halogen over at least some internal surfaces of a plasma
4 etch chamber. After forming the polymer, plasma etching is conducted
5 using a gas which is effective to etch polymer from chamber internal
6 surfaces. In one implementation, the gas has a hydrogen component
7 effective to form a gaseous hydrogen halide from halogen liberated from
8 the polymer. In one implementation, the gas comprises a carbon
9 component effective to getter the halogen from the etched polymer. In
10 another implementation, a plasma etching method includes positioning a
11 semiconductor wafer on a wafer receiver within a plasma etch chamber.
12 First plasma etching of material on the semiconductor wafer occurs with
13 a gas comprising carbon and a halogen. A polymer comprising carbon
14 and the halogen forms over at least some internal surfaces of the
15 plasma etch chamber during the first plasma etching. After the first
16 plasma etching and with the wafer on the wafer receiver, second plasma
17 etching is conducted using a gas effective to etch polymer from chamber
18 internal surfaces and getter halogen liberated from the polymer to
19 restrict further etching of the material on the semiconductor wafer
20 during the second plasma etching. The first and second plasma etchings
21 are ideally conducted at subatmospheric pressure with the wafer
22 remaining *in situ* on the receiver intermediate the first and second
23 etchings, and with the chamber maintained at some subatmospheric
24 pressure at all time intermediate the first and second plasma etchings.

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EL054831987
EL465851515

1 **DECLARATION OF JOINT INVENTORS FOR PATENT APPLICATION**

2 As the below named inventor, I hereby declare that:

3 My residence, post office address and citizenship are as stated
4 below next to my name.

5 I believe I am the original, first and joint inventor of the subject
6 matter which is claimed and for which a patent is sought on the
7 invention entitled: **Plasma Etching Methods**, the specification of which
8 is attached hereto.

9 I hereby state that I have reviewed and understand the contents
10 of the above-identified specification, including the claims.

11 I acknowledge the duty to disclose information known to me to
12 be material to patentability as defined in Title 37, Code of Federal
13 Regulations §1.56.

14 **PRIOR FOREIGN APPLICATIONS:**

15 I hereby state that no applications for foreign patents or inventor's
16 certificates have been filed prior to the date of execution of this
17 declaration.

18 I hereby declare that all statements made herein of my own
19 knowledge are true and that all statements made on information and
20 belief are believed to be true; and further that these statements were
21 made with the knowledge that willful false statements and the like so
22 made are punishable by fine or imprisonment, or both, under
23 Section 1001 of Title 18 of the United States Code and that such willful
24

false statement may jeopardize the validity of the application or any patent issued therefrom.

* * * * * * * * * *

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